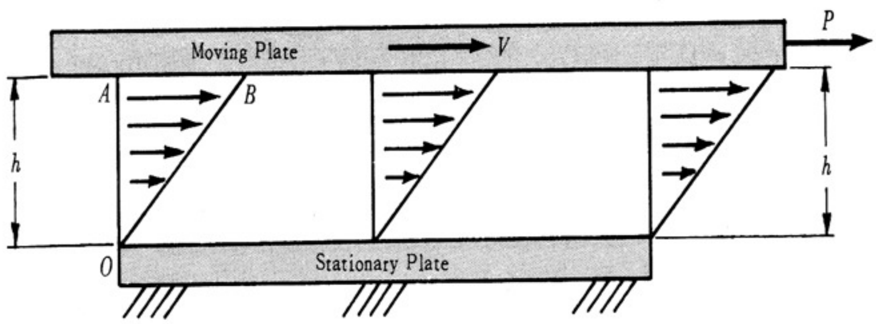
Sliding Bearings

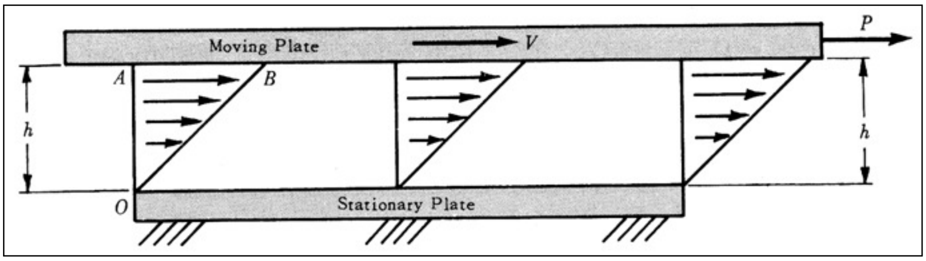
Part 1

Viscosity

Consider:
A moving plate by force P.
A stationary plate.
A lubricant in between.
The two plates are parallel.



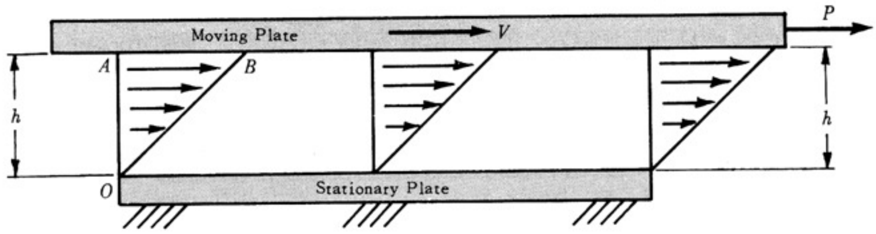
Viscosity



The particles of the lubricant adhere strongly to the moving and stationary plates.

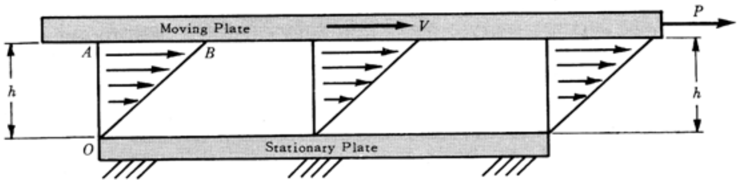
Motion is accompanied by a linear slip or shear between the lubricant layers.

Viscosity



Newton found that:
The magnitude of the shearing stress varies directly with the velocity of the moving plate.
The magnitude of the shearing stress varies inversely with the film thickness h.

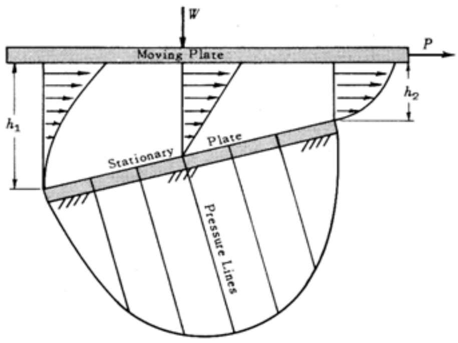
Viscosity



When the two plates are parallel:
1 The velocity is proportional to the distance from the stationary plate.
2

3

Viscosity



When the two plates are inclined:
1

2

Viscosity

1. **Absolute Viscosity or Dynamic Viscosity**

Method of Representation		
Reyn after Reynolds	**Poise** after Poiseuille	**SI metric units**
Lbf sec/in^2	Dyne sec/cm^2	Ns/m^2
	1 kg = 9.8 * 10^5 dyne 1 kg = 9.8 N	Poiseuille (PI) = 1 Ns/m^2
		1 P = 0.1 PI = 0.1 Ns/m^2 1 cP = 0.01 P = 0.001 Ns/m^2
		P = Poise cP = Centipoise

Viscosity

2. **Kinematic Viscosity**

Method of Representation
Stokes
m^2/s
1 St = 10^{-4} m^2/s
1 cSt = 10^{-6} m^2/s

Relationship between Dynamic and Kinematic Viscosities

$Z = \upsilon * \gamma / g$

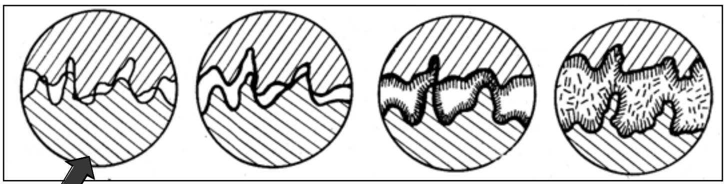
Z = Dynamic or Absolute Viscosity, Ns/m^2

υ = Kinematic Viscosity, m^2/s

γ = Density, N/m^3 , (average value = 0.85-0.90 g/cm^3)

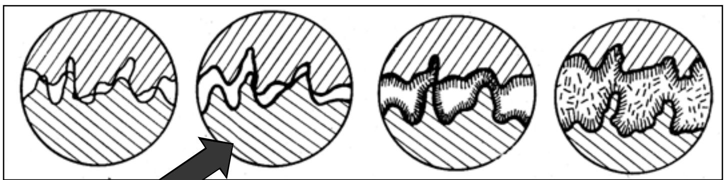
g in m/s^2

Friction



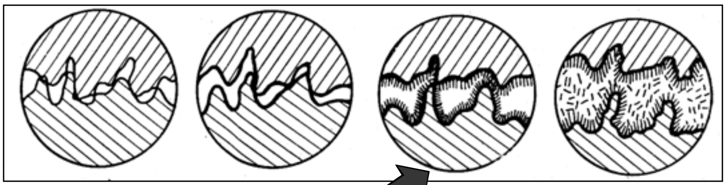
Dry Friction:
1

Friction



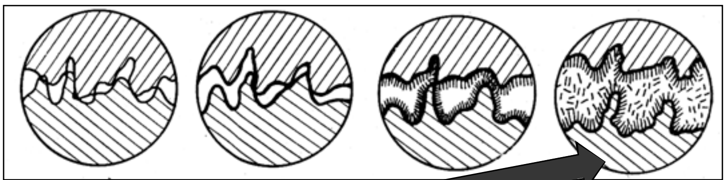
Semi-Dry Friction:
1 Absence of any added lubricant.

Friction



Boundary Friction:
1

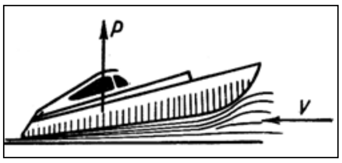
Friction

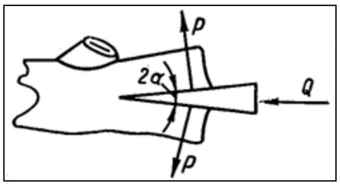


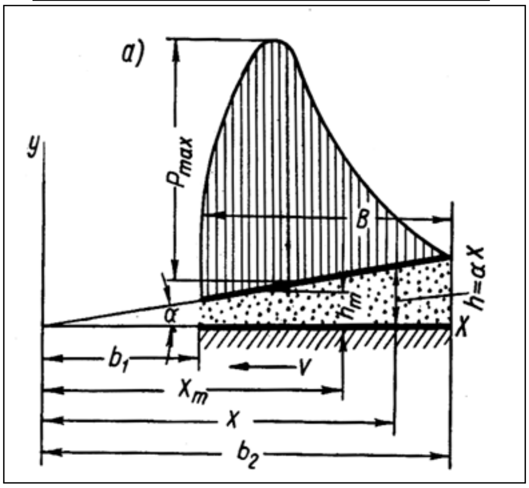
Fluid Friction:
1 Presence of a complete film of lubricant.

Lubrication

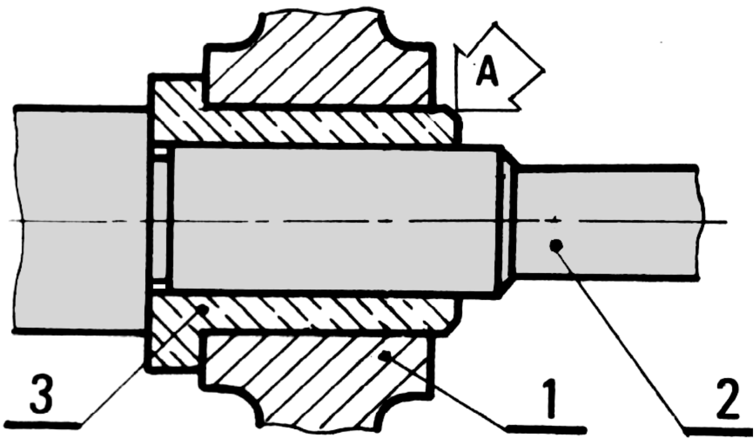
Wedge Action Principle



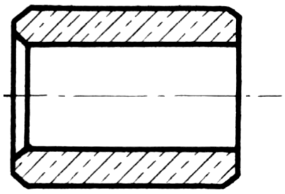




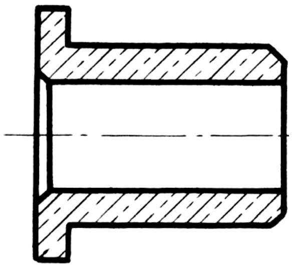
Assembly of a Bush



Bearing Bushes – Journal Bearing



Simple Bush

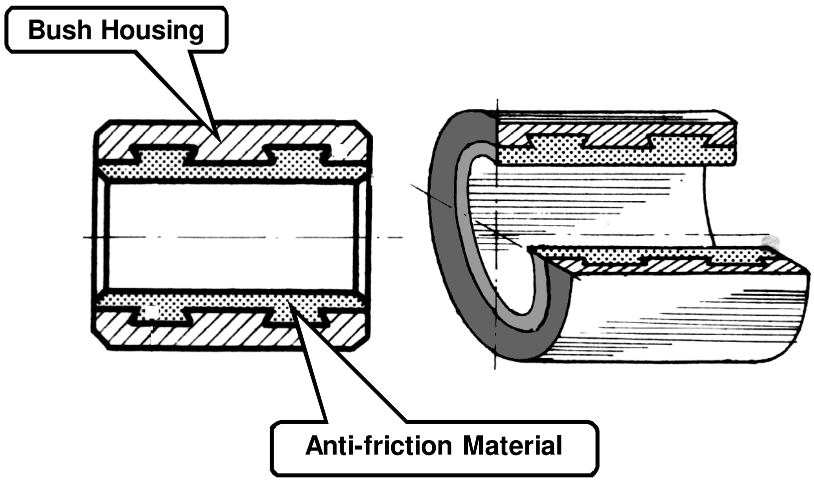


Bush with Shoulder

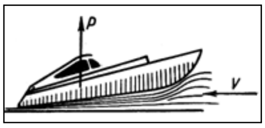
Materials:

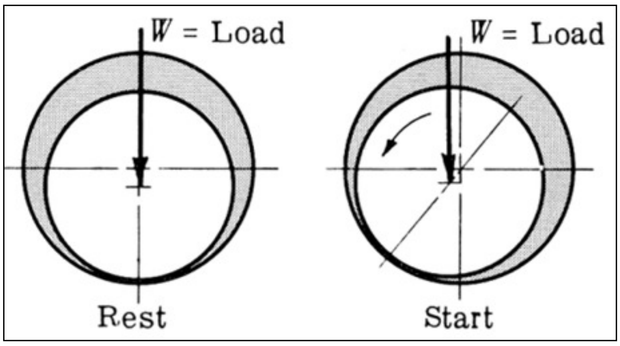
CI, PhBr, Plastics, ..

Bearing Bushes

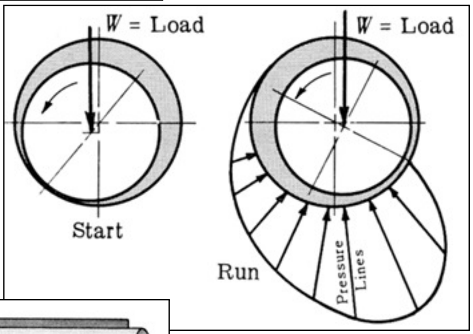


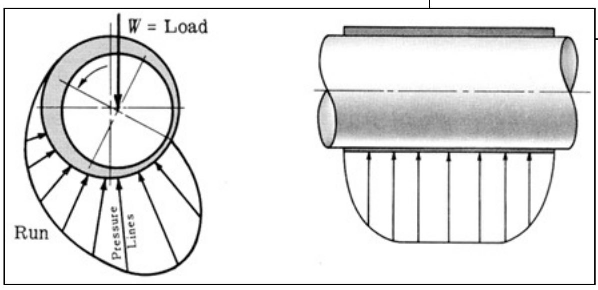
Lubrication



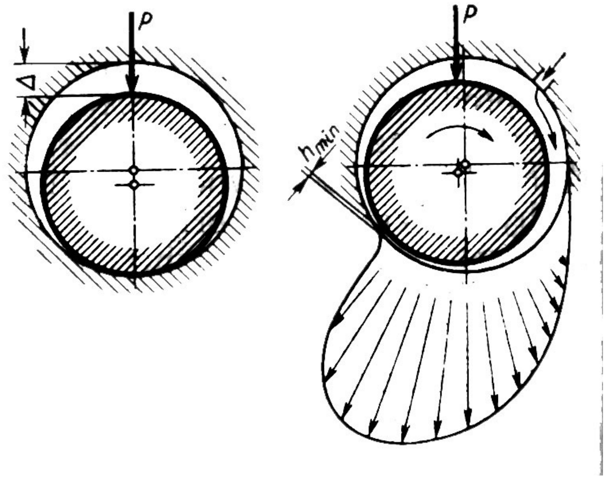


Lubrication

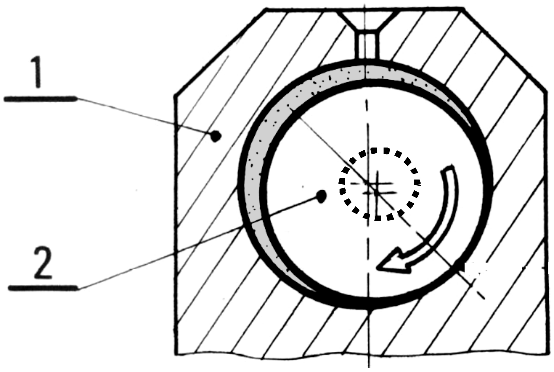




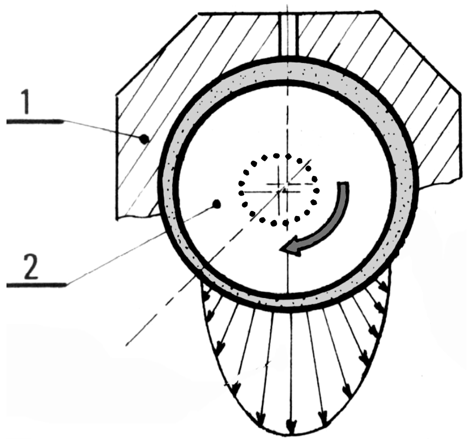
Hydrodynamic Action

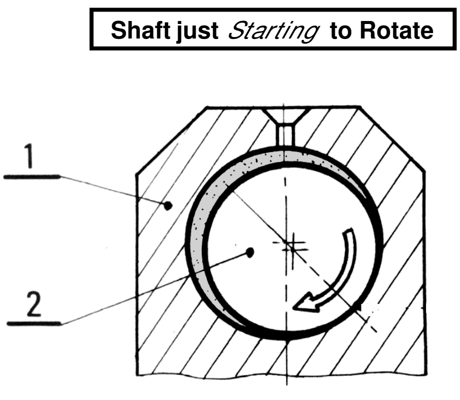


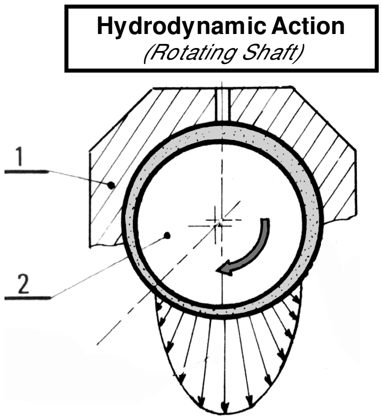
Shaft just *Starting* to Rotate



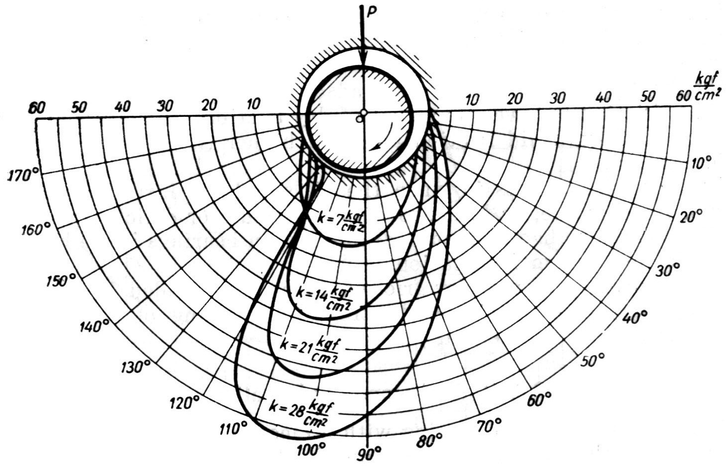
Hydrodynamic Action
(Rotating Shaft)



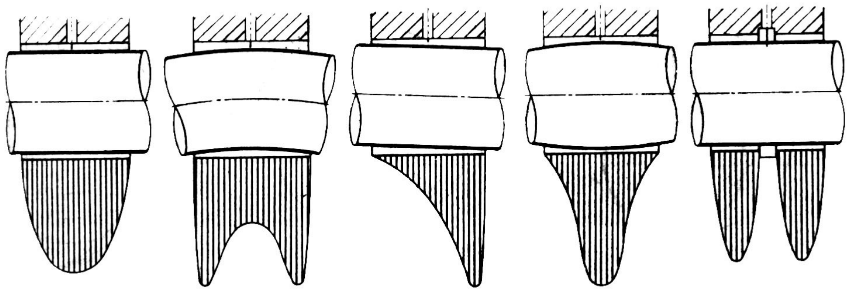




Hydrodynamic Action
(radial pressure distribution)



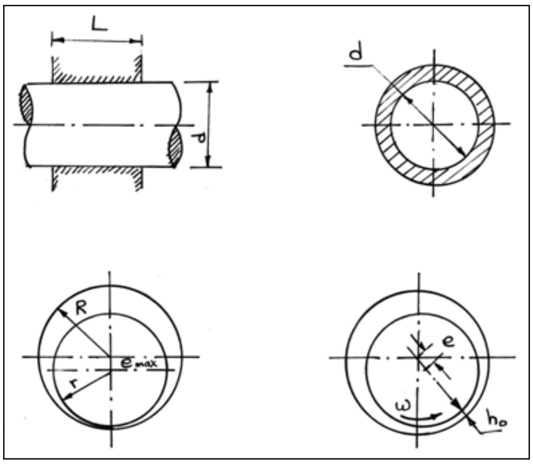
Hydrodynamic Action
(axial pressure distribution due to shaft errors)



Bearing Dimensionless Ratios

1

Breadth ratio: β

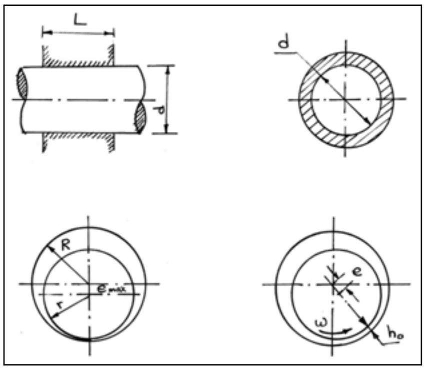


β = 0.6 - 1.5 Normal loading
0.4 – 0.6 Heavy loading

Bearing Dimensionless Ratios

2

Clearance ratio: ψ

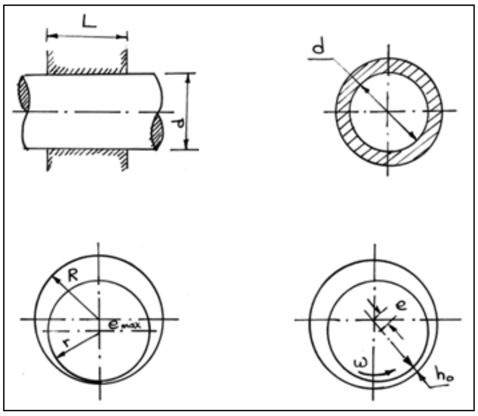


ψ =	0.0020 – 0.0030	High speed and Moderate pressure
	0.0015 – 0.0025	High speed and High pressure
	0.0007 – 0.0012	Very low speed and Moderate pressure
	0.0003 – 0.0006	Very low speed and High pressure

Bearing Dimensionless Ratios

3

Eccentricity ratio: ε



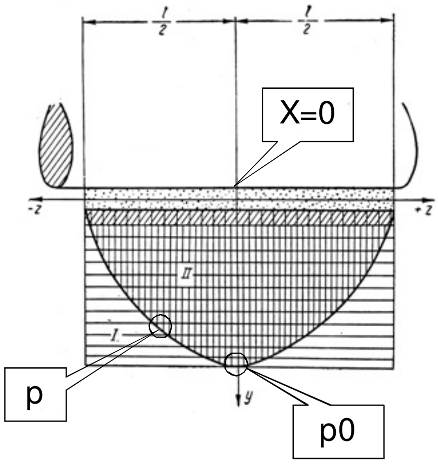
ε = 0.7 – 0.9	Normal loading
0.5 – 0.7	Heavy loading

Pressure Distribution Equation

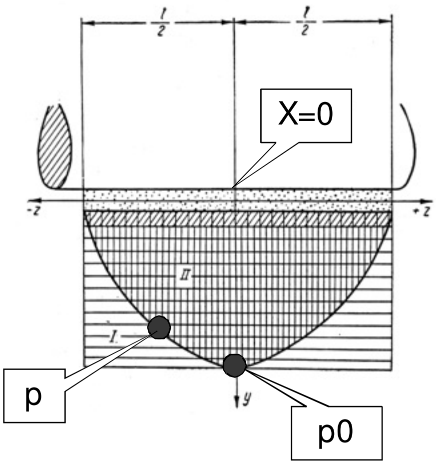
p = Pressure at any point on the parabola

p0 = Max parabola pressure

m =



Pressure Distribution Equation



p0 = Max parabola pressure

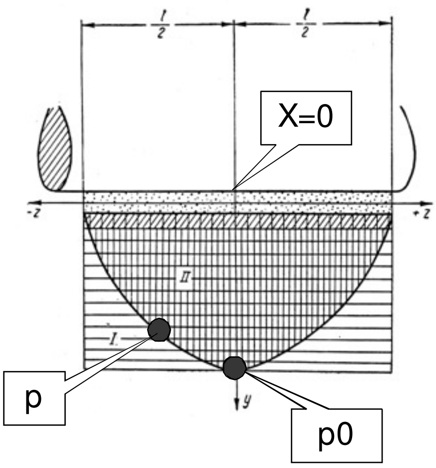
Π0 =

Z = Absolute or Dynamic Viscosity

ψ = Clearance Ratio

ω = Angular Velocity

Pressure Distribution Equation



pm =

Πm = Dimensionless Parameter

Z = Absolute or Dynamic Viscosity

ψ = Clearance Ratio

ω = Angular Velocity

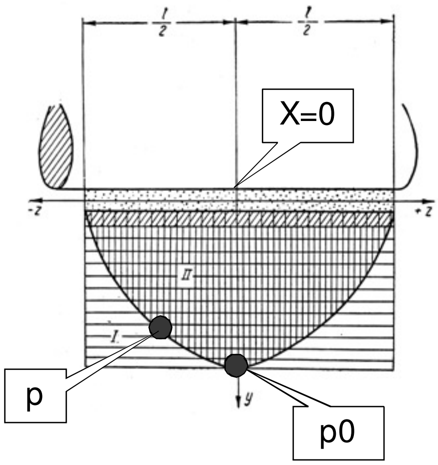
Pressure Distribution Equation

N/m2

$$\Pi_m = p_m \cdot \frac{\Psi^2}{Z.\omega}$$

Ns/m2

Rad/s



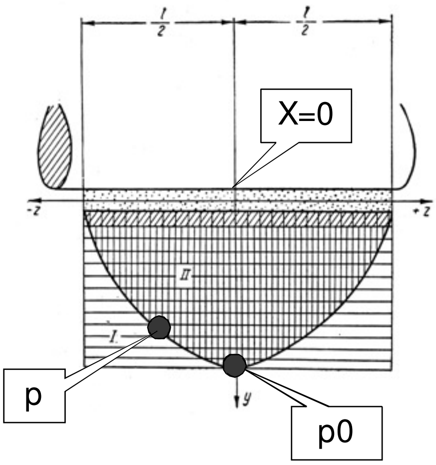
Bearing Characteristic Number

Various investigators, employing dimensional analysis, have shown that the journal coefficient of friction is a function of at least three dimensionless parameters,

ZN/p, D/C, and L/D

All three parameters are DIMENSIONLESS

Pressure Distribution Equation



Πm is a function of

Bearing Index Number π_m

Values of Πm versus β and ε

ε	β							ε
	0.5	0.75	1.0	1.25	1.5	1.75	2.0	
0.1	0.0329	0.068	0.109	0.150	0.190	0.225	0.257	0.1
0.2	0.0697	0.143	0.226	0.311	0.391	0.463	0.526	0.2
0.3	0.115	0.233	0.365	0.496	0.618	0.727	0.822	0.3
0.4	0.117	0.351	0.540	0.724	0.892	1.040	1.167	0.4
0.5	0.268	0.518	0.728	1.029	1.259	1.439	1.599	0.5
0.6	0.415	0.779	1.148	1.477	1.759	1.996	2.192	0.6
0.7	0.679	1.236	1.771	2.219	2.585	2.881	3.117	0.7
0.8	1.253	2.208	3.062	3.720	4.221	4.601	4.891	0.8
0.9	3.134	5.320	7.118	8.339	9.167	9.731	10.120	0.9
ε	0.5	0.75	1.0	1.25	1.5	1.75	2.0	ε
	β							

Pressure Distribution Equation

$$\Pi_m = p_m \cdot \frac{\psi^2}{Z.\omega}$$

Πm is a function of

Design Procedure

We can assume

When ω is known

But

Thus the design is completed

Coefficient of Friction according to McKee

Z: kg.sec/sq.cm

p: kg/sq.cm

N: rpm

Always work in the